Monitoring of the Radiative Forcing of Greenhouse Gases with Satellite and Ground Instruments

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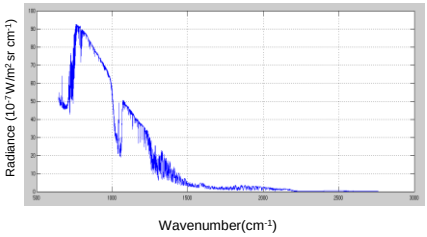
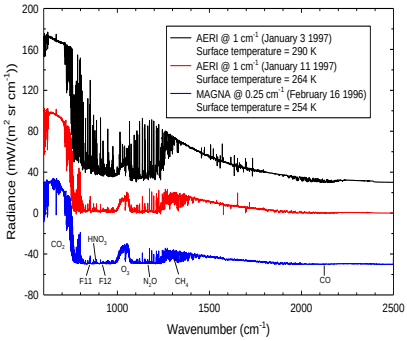
IASI Nadir Spectrum at 44N, 78 W in February



Comparison of a Great Lakes Spectrum with an AERI Spectrum

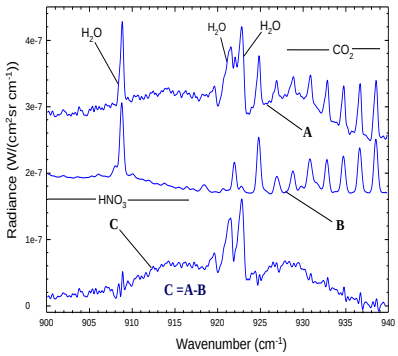


Measurements of Spectral Sky Irradiance with a ABB BOMEM AERI FTS

A Comparison of the IASI TOA Radiative Forcing with the Surface Forcing of Greenhouse Gases at 44N,78W Feb

Greenhouse Gas	IASI Radiative Trapping (W/m^2)	Surface Forcing (W/m^2)
methane	1.08	0.96
nitrous oxide	1.08	1.04
ozone	3.90	3.27
CFC-11	0.08	0.11
CFC-12	0.20	0.24
nitric acid	0.055	0.06

Extraction of the Thermal Emission Band of CFC-12 from the Measured Atmospheric Emission Spectrum



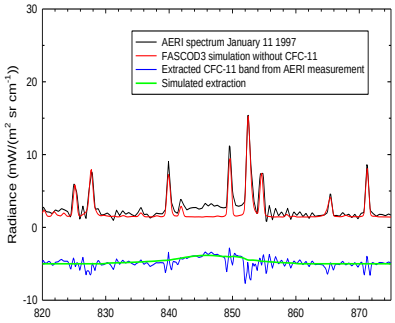
Comparison of Great Lakes and AERI Winter Surface Greenhouse Fluxes

Greenhouse Gas	Emission Band (cm^{-1})	GL Flux (W/m^2)	AERI Flux (W/m^2)
CFC-11	830 - 860	0.10	0.12
CFC-12	all bands	0.21	0.26
CFC-11 + 12	all bands	0.31	0.38
CH_4	1200 - 1400	1.02	1.21
N_2O	1200 - 1300	1.19	1.32
O_3	900 - 1100	3.34	3.02
CO_2	all bands	30.9	37.3

Validation of Radiative Forcing in GCMs

- The term "radiative forcing", as employed in the IPCC Assessments, is the radiative forcing of the surface-troposphere system due to a perturbation (such as a change in greenhouse gas concentrations) it is the change in net (down minus up) irradiance (solar plus long-wave; in Wm^{-2}) at the tropopause AFTER allowing for stratospheric temperatures to readjust to radiative equilibrium, but with surface and tropospheric temperatures and state held fixed at the unperturbed values.
- Radiative forcing defined this way cannot be observed in the real world and is a metric, not an observable. Radiative forcing in IPCC models is essentially unvalidated.
- Surface radiative forcing is approximately equal to - radiative forcing metric
- It is technically possible to measure RF and to use this data to validate GCMs. Clouds alter RF.
- RF is so fundamental to climate change that it is essential to validate against the physical world.
- This type of measurement is a logical extension of NOAA pyrgeometer thermal irradiance measurements into the spectral domain

Comparison of an AERI Spectrum for the 850 cm^{-1} Band of CFC11 at 1 cm^{-1} Resolution with a MODTRAN Simulation at 1 cm^{-1}



Locations of AERI Instruments: the network

- 1 at U of Winnipeg, Manitoba
- 1 at PEARL in Eureka, Nunavut
- 1 at Imperial College, UK
- 1 at U of Wisconsin, WI
- 7 at 4 ARM sites.
  - NSA, Alaska
  - Darwin, Australia
  - TWP Nauru, equator
  - SGP Central Facility, Lamont, OK
  - SGP Lamont, OK (secondary)
  - mobile facility
- plus 3 onboard ships U Miami

Acknowledgements

Support and advice from ABB BOMEM
IASI spectra from Hank revercomb

Measured greenhouse fluxes at the Earth's surface

Greenhouse Gas	Emission Band (cm^{-1})	Measured Flux (W/m^2)	Simulated Flux (W/m^2)
CFC11	830 - 860	0.14	0.12
CFC12	900 - 940	0.12	0.11
CFC12	all bands	0.28	0.26
CFC11 & 12	all bands	0.42	0.38
CCl_4	786 - 806	0.046	0.039
CFC113	800 – 830	NA	0.033
HCFC22	780 - 830	NA	0.031
HNO_3	850 - 920	0.085	0.060
N_2O	all bands	0.69	0.67
CH_4	1200 – 1400	0.85	0.80
CO	2000 – 2200	0.032	0.033
CO_2	all bands	21.0	20.2
O_3	950 – 1100	3.26	3.20
Tropospheric O_3	950 – 1100	0.61	0.58

Comparison of measured surface greenhouse fluxes with simulated fluxes from two GCMs

Greenhouse Gas	U.S. CCM3 Flux (W/m^2)	Canadian GCM3 Flux (W/m^2)	Measured Flux (W/m^2)
H_2O	198.6 (-2.2%)	195.6 (-3.6%)	203.0
CO_2	21.8 (-14%)	22.3 (-12%)	25.3
CH_4	1.89 (+90%)	1.37 (+38%)	0.994
N_2O	1.22 (+30%)	2.03 (+117%)	0.936
O_3	3.40 (+10%)	3.36 (+9.1%)	3.08
CFC11	0.14 (+27%)	0.20 (+82%)	0.11
CFC12	0.30 (+25%)	0.50 (+108%)	0.24
TOTAL	227.4 (-2.7%)	225.4 (-3.6%)	233.7

SHORT SUMMARY

AERI GHG Thermal Irradiance measurements can

- Validate radiative forcing measured with nadir overpasses of satellites such as IASI.
- Validate the annual greenhouse gas index (AGGI).
- Validate the radiative forcing by GHGs in GCMs.
- Evaluate the reduction of GHG radiative forcing by clouds.
- Study seasonal and climate regime variations of surface radiative forcing.
- Monitor trends in the climate forcing radiation from each GH gas.
- Enhance the monitoring of LW radiation with pyrgeometers
- Facilitate a world network for observation of the climate forcing from greenhouse gases